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Comparison of column-averaged dry-air mole fractions of CO_2 retrieved from TCCON ground-based FTIRs to Atmospheric Transport Model simulations

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Column-averaged dry-air mole fractions (e.g. XCO_2, XCH4) retrieved from ground-based solar absorption within the TCCON have proven to play an important role in carbon cycle research. This role comprises validation of satellites and models, and carbon cycle science in their own right. In this paper, we present comparisons of column-averaged dry-air mole fractions retrieved from TCCON spectra to Atmospheric Transport Model simulations. Firstly, we present the correct method for smoothing the model simulated vertical columns to account for the TCCON averaging kernels and a priori profiles. We also address the sensitivities to aspects of the smoothing, such as a site-independent solar zenith angle dependent parameterisation of the averaging kernel and the importance of having a realistic a priori profile.

Following that, we show comparison of the TCCON XCO_2 to model simulations, e.g. from CarbonTracker and a TM3 tagged tracer simulation. Both CarbonTracker and the TM3 simulation feature decomposition of the total CO_2 signature by source process, while the TM3 simulation also decomposes these further according to the geographical source (or sink) region. We focus on the long-term and seasonal agreement of the model and measurement time series. Previously, comparisons of model simulations with TCCON measurements have shown that the models underestimate the amplitude of the northern hemispheric seasonal cycle. Here we show that recent model simulations show considerably better agreement with TCCON data with respect to the amplitude of the seasonal cycle than has previously been reported. We investigate driving factors behind this improved agreement, especially with respect to changes in assimilated or inverted fluxes. We also discuss the drivers of variability in the column data as determined by the tagged tracer simulations.